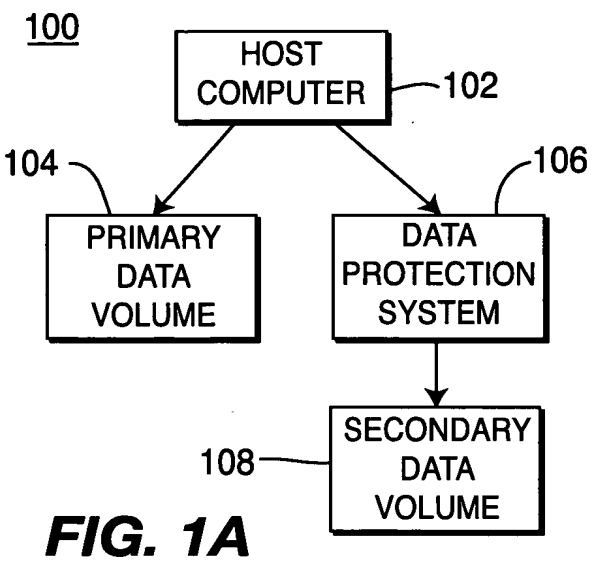

FIG. 1A

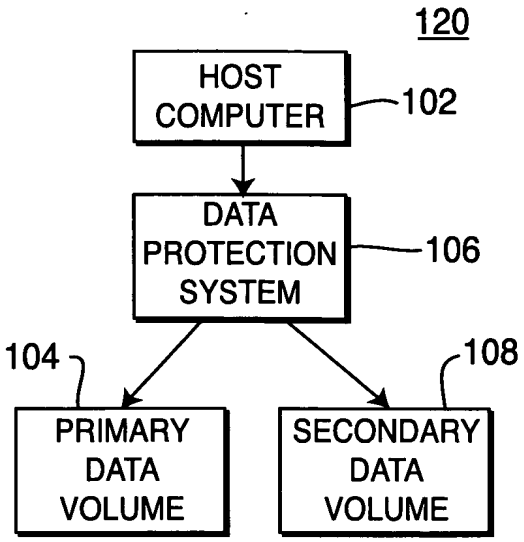

FIG. 1B

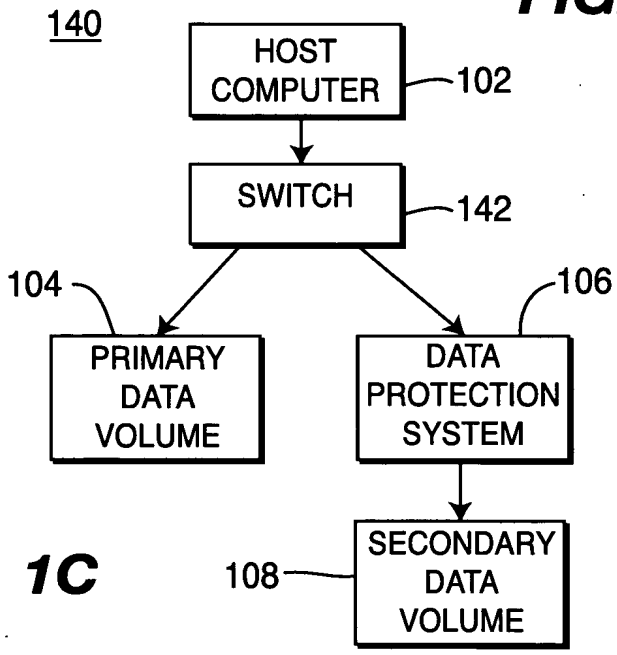

FIG. 1C

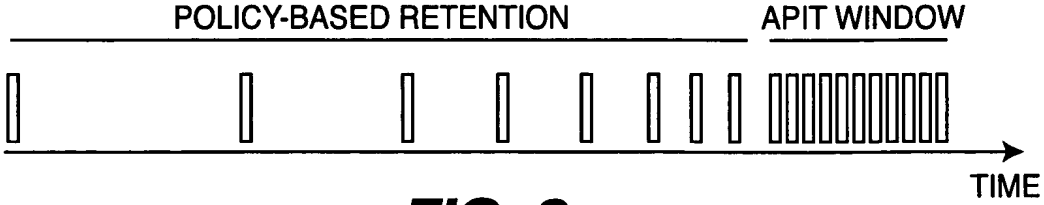

FIG. 8

DELTA REGION	MAP OFFSET	FORMAT OFFSET ON SECONDARY	PHYSICAL DEVICE
.1 = NO PHYSICAL DEVICE USAGE			

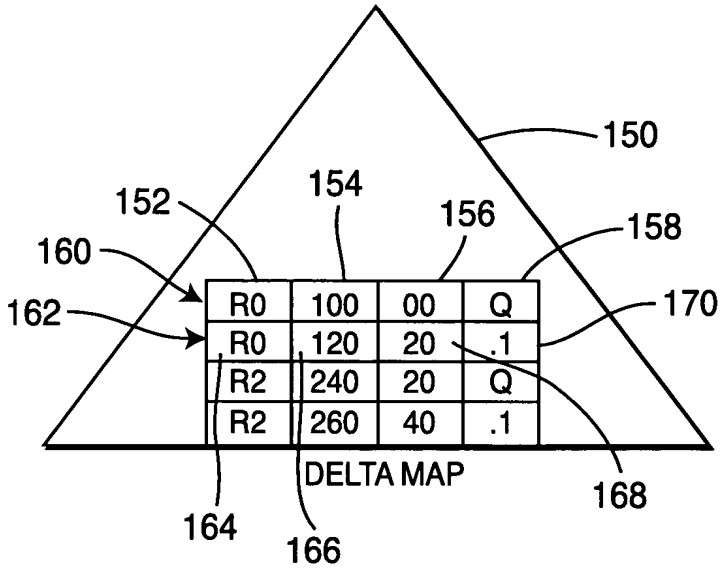

FIG. 2

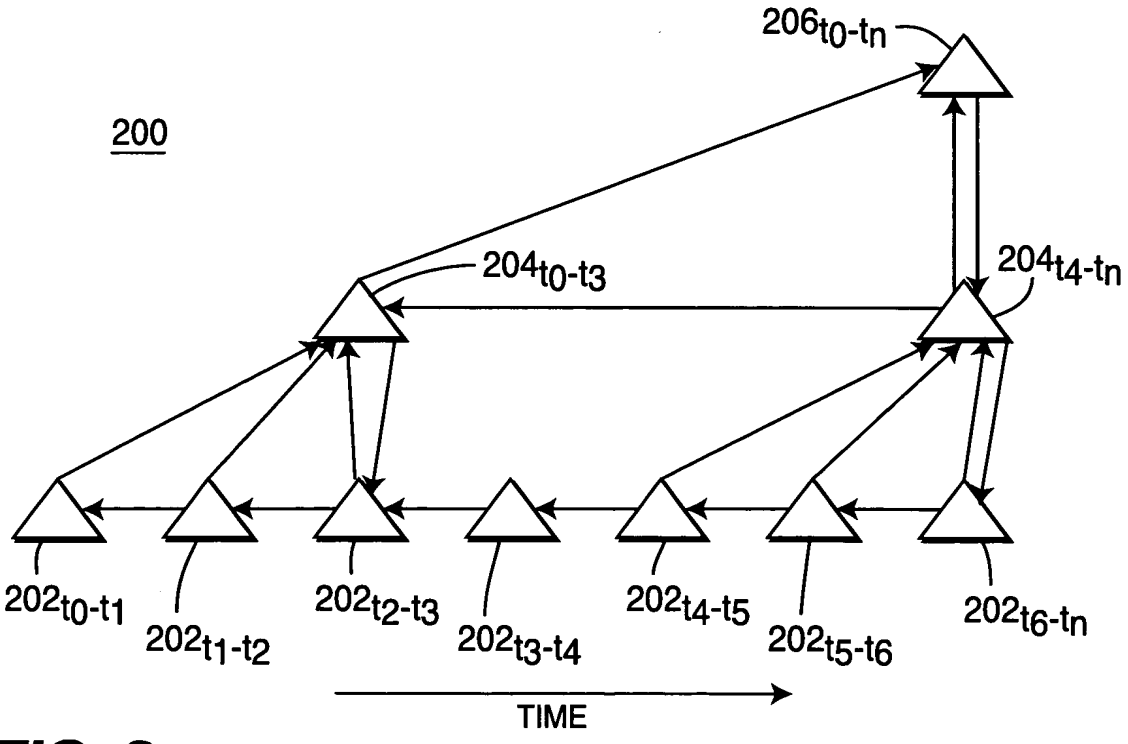

FIG. 3

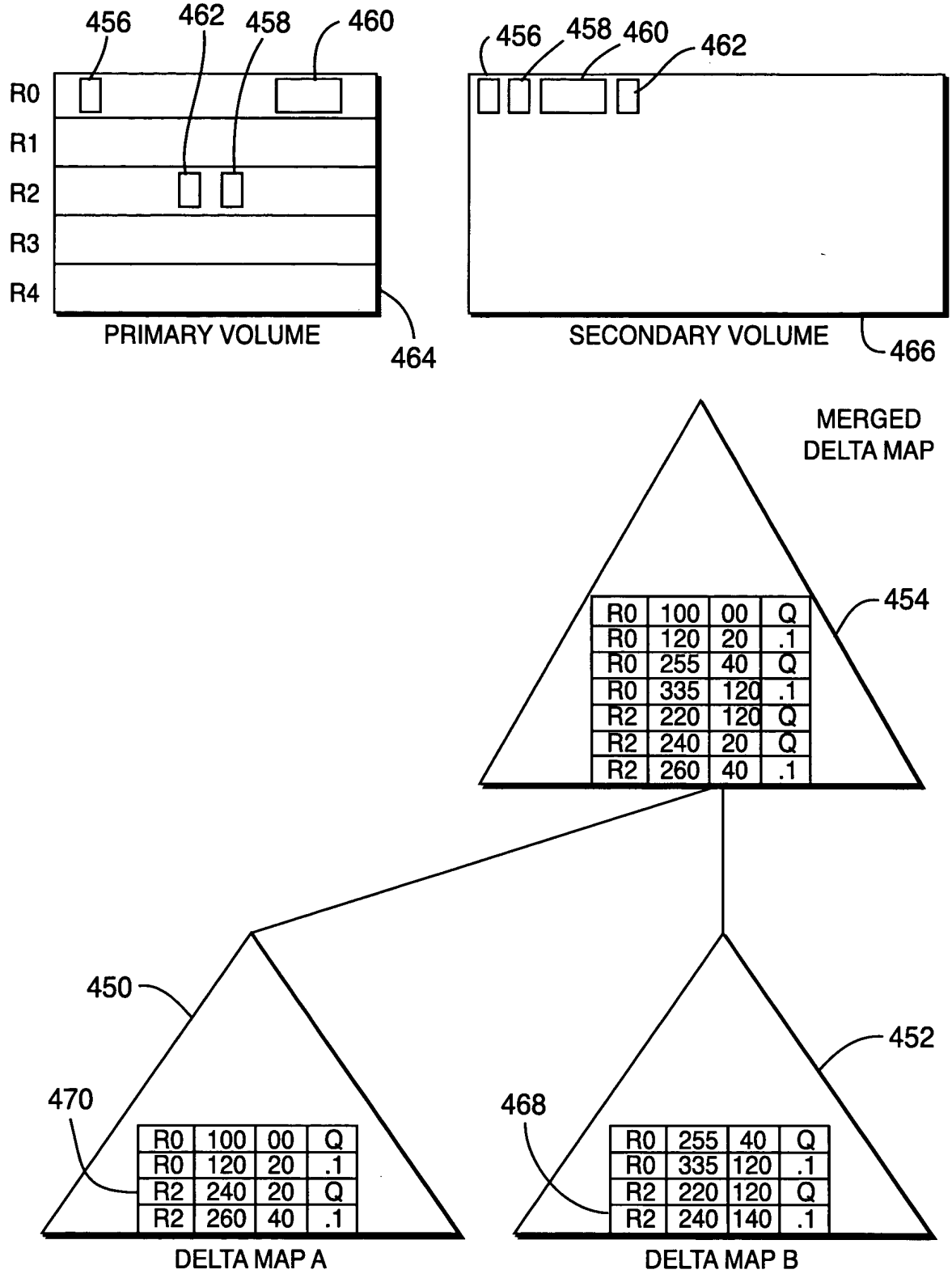
456
462
458
460
R0
R1
R2
R3
R4
PRIMARY VOLUME
464
456
458
460
462
SECONDARY VOLUME
466
MERGED
DELTA MAP
454
R0 100 00 Q
R0 120 20 .1
R0 255 40 Q
R0 335 120 .1
R2 220 120 Q
R2 240 20 Q
R2 260 40 .1
450
470
R0 100 00 Q
R0 120 20 .1
R2 240 20 Q
R2 260 40 .1
DELTA MAP A
452
468
R0 255 40 Q
R0 335 120 .1
R2 220 120 Q
R2 240 140 .1
DELTA MAP B

FIG. 4

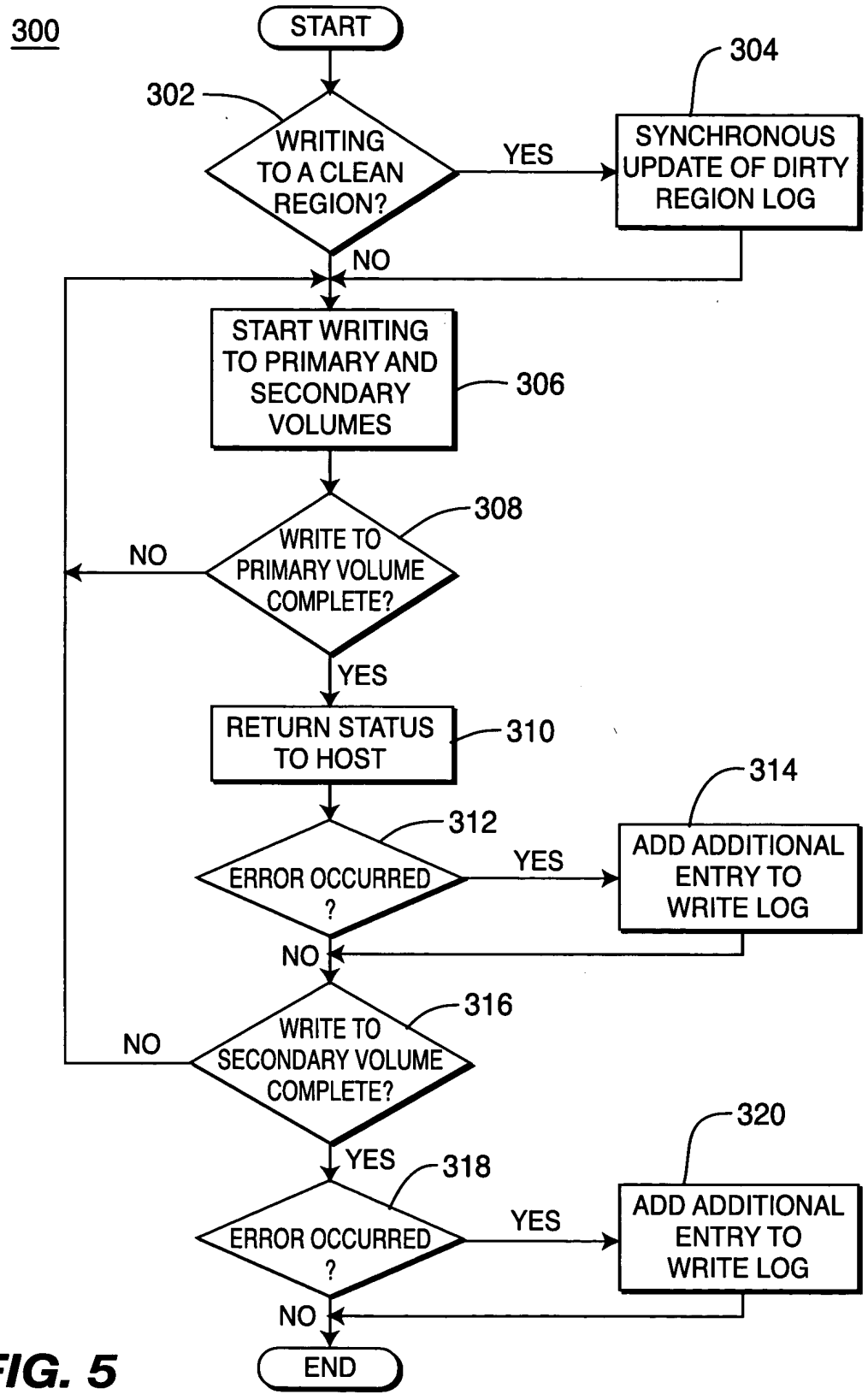
300
START
302
WRITING TO A CLEAN REGION?
YES
304
SYNCHRONOUS UPDATE OF DIRTY REGION LOG
NO
START WRITING TO PRIMARY AND SECONDARY VOLUMES
306
308
WRITE TO PRIMARY VOLUME COMPLETE?
NO
YES
RETURN STATUS TO HOST
310
314
312
ERROR OCCURRED ?
YES
ADD ADDITIONAL ENTRY TO WRITE LOG
NO
316
WRITE TO SECONDARY VOLUME COMPLETE?
NO
YES
320
318
ERROR OCCURRED ?
YES
ADD ADDITIONAL ENTRY TO WRITE LOG
NO
END

FIG. 5

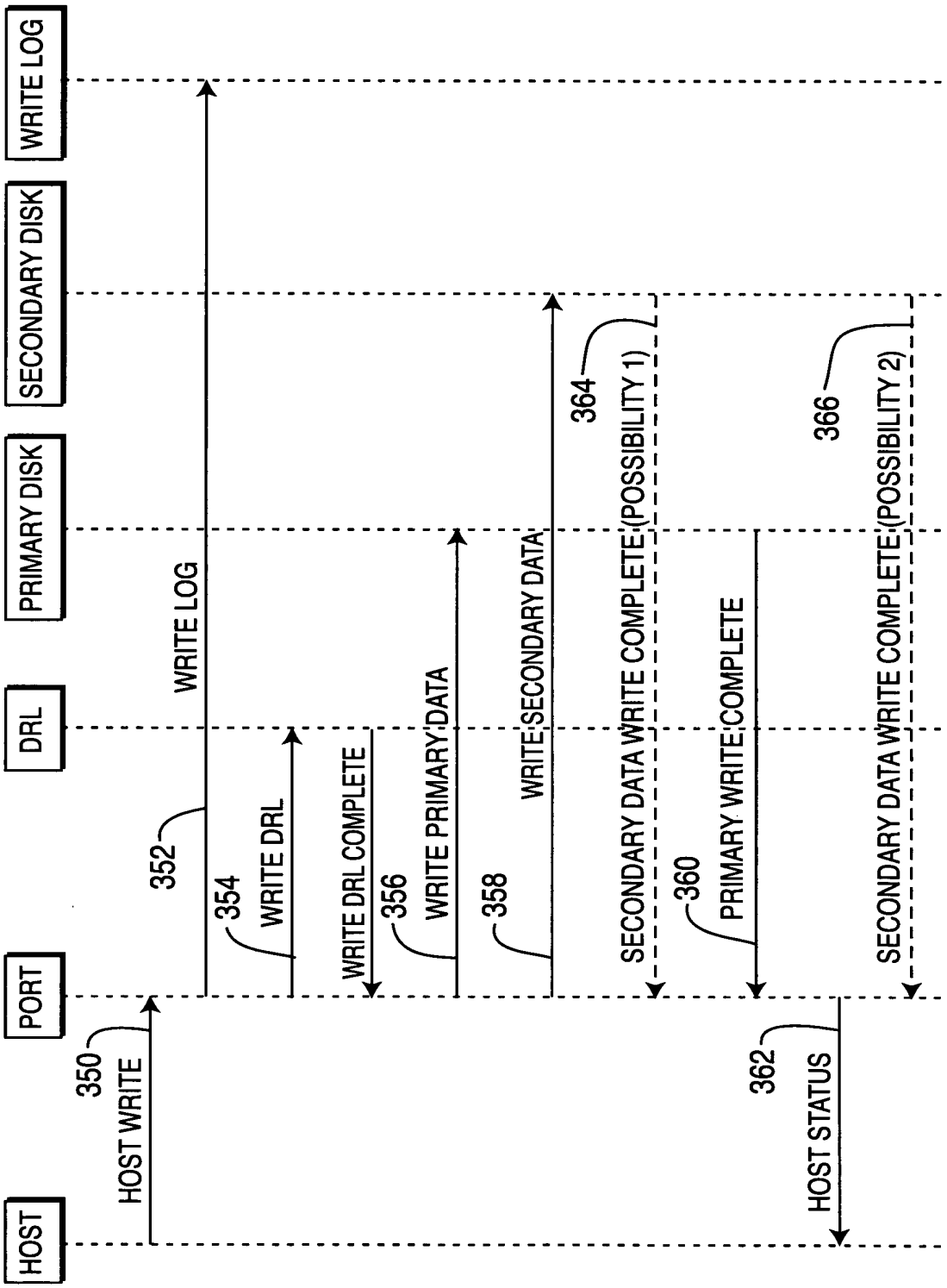
HOST
PORT
DRL
PRIMARY DISK
SECONDARY DISK
WRITE LOG
350
HOST WRITE
352
WRITE LOG
354
WRITE DRL
WRITE DRL COMPLETE
356
WRITE PRIMARY DATA
358
WRITE SECONDARY DATA
364
SECONDARY DATA WRITE COMPLETE (POSSIBILITY 1)
360
PRIMARY WRITE COMPLETE
362
HOST STATUS
366
SECONDARY DATA WRITE COMPLETE (POSSIBILITY 2)

FIG. 6

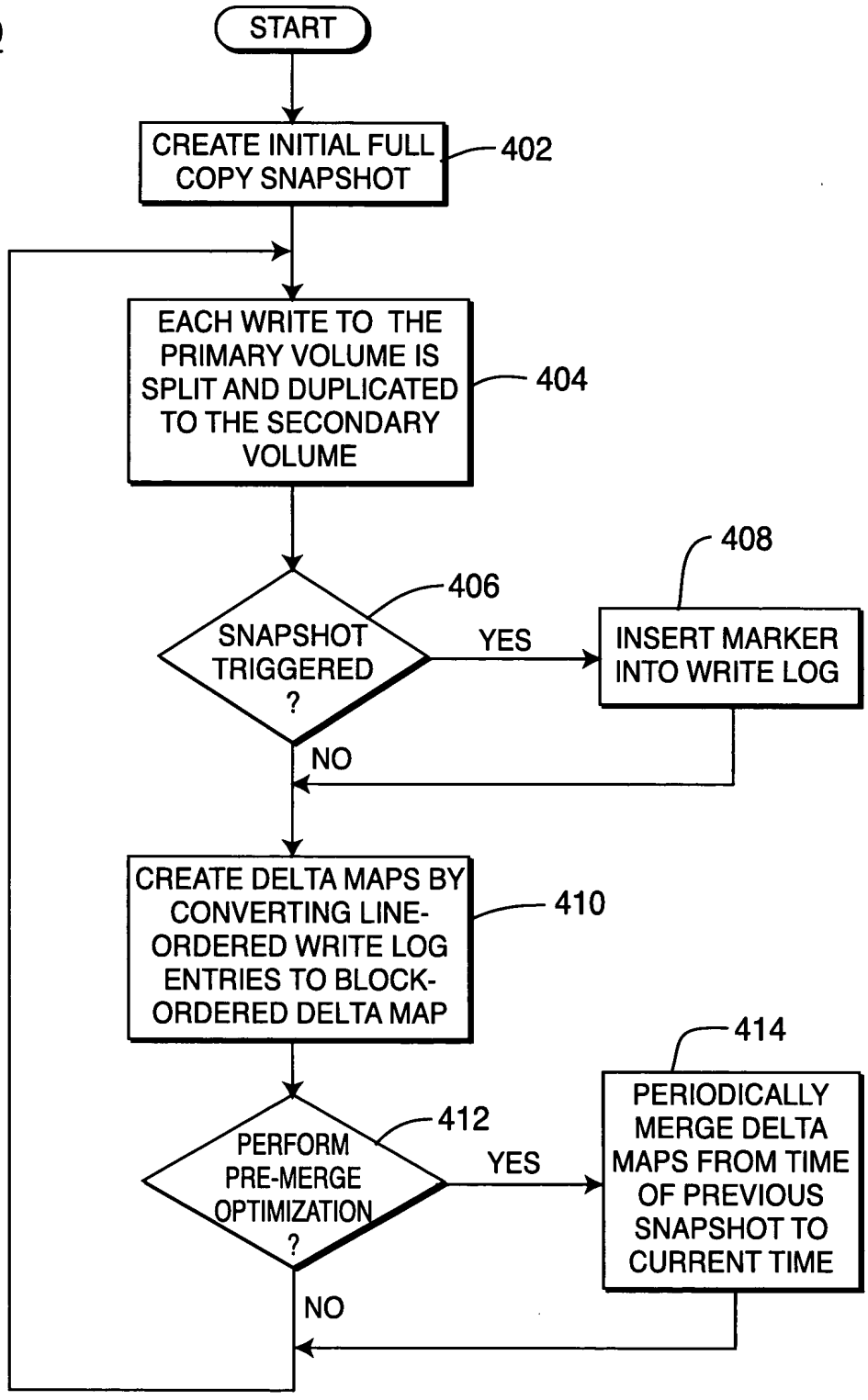
400
START
CREATE INITIAL FULL COPY SNAPSHOT
402
EACH WRITE TO THE PRIMARY VOLUME IS SPLIT AND DUPLICATED TO THE SECONDARY VOLUME
404
SNAPSHOT TRIGGERED ?
406
YES
INSERT MARKER INTO WRITE LOG
408
NO
CREATE DELTA MAPS BY CONVERTING LINE-ORDERED WRITE LOG ENTRIES TO BLOCK-ORDERED DELTA MAP
410
PERFORM PRE-MERGE OPTIMIZATION ?
412
YES
PERIODICALLY MERGE DELTA MAPS FROM TIME OF PREVIOUS SNAPSHOT TO CURRENT TIME
414
NO

FIG. 7

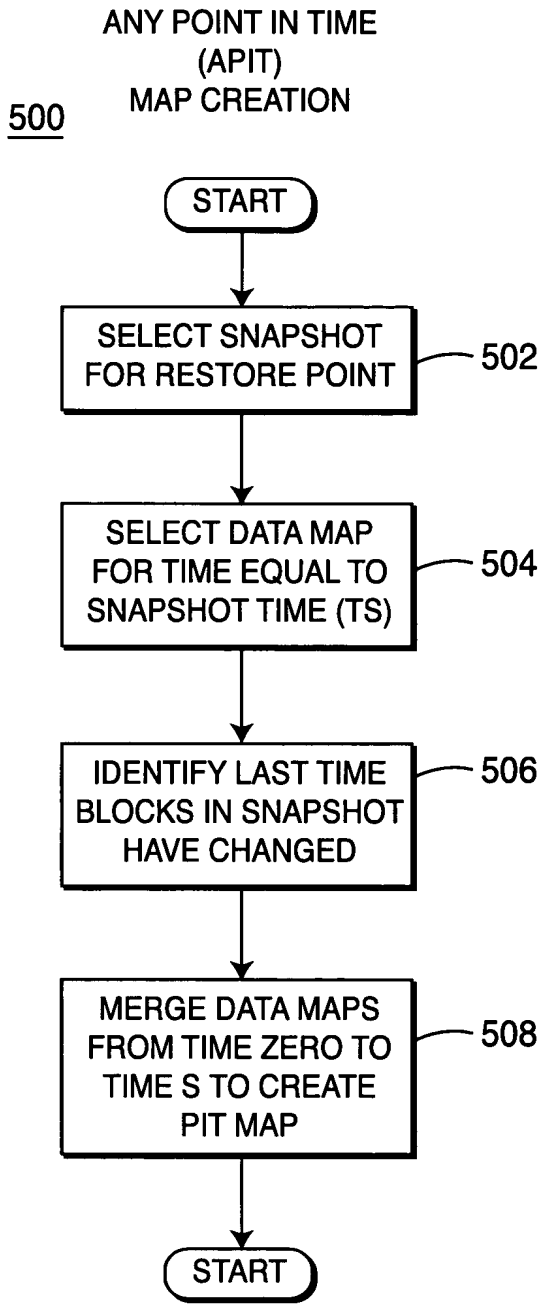
ANY POINT IN TIME
(APIT)
MAP CREATION
500
START
SELECT SNAPSHOT FOR RESTORE POINT
502
SELECT DATA MAP FOR TIME EQUAL TO SNAPSHOT TIME (TS)
504
IDENTIFY LAST TIME BLOCKS IN SNAPSHOT HAVE CHANGED
506
MERGE DATA MAPS FROM TIME ZERO TO TIME S TO CREATE PIT MAP
508
START

FIG. 9

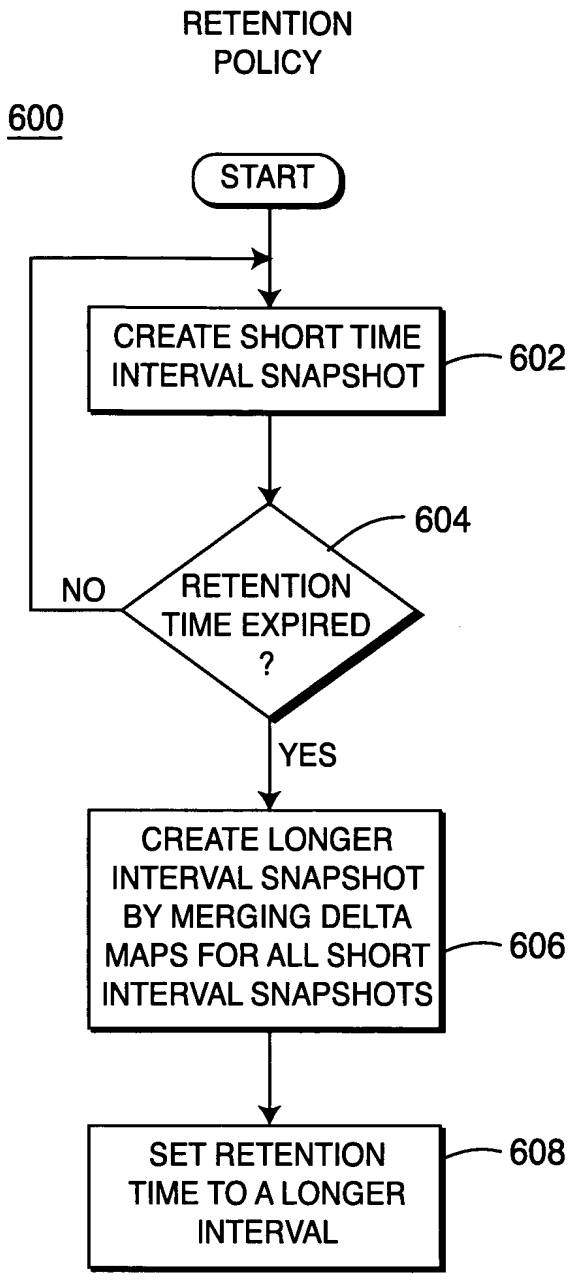
RETENTION
POLICY
600
START
CREATE SHORT TIME INTERVAL SNAPSHOT
602
604
NO
RETENTION TIME EXPIRED ?
YES
CREATE LONGER INTERVAL SNAPSHOT BY MERGING DELTA MAPS FOR ALL SHORT INTERVAL SNAPSHOTS
606
SET RETENTION TIME TO A LONGER INTERVAL
608

FIG. 10